FIG. 1.

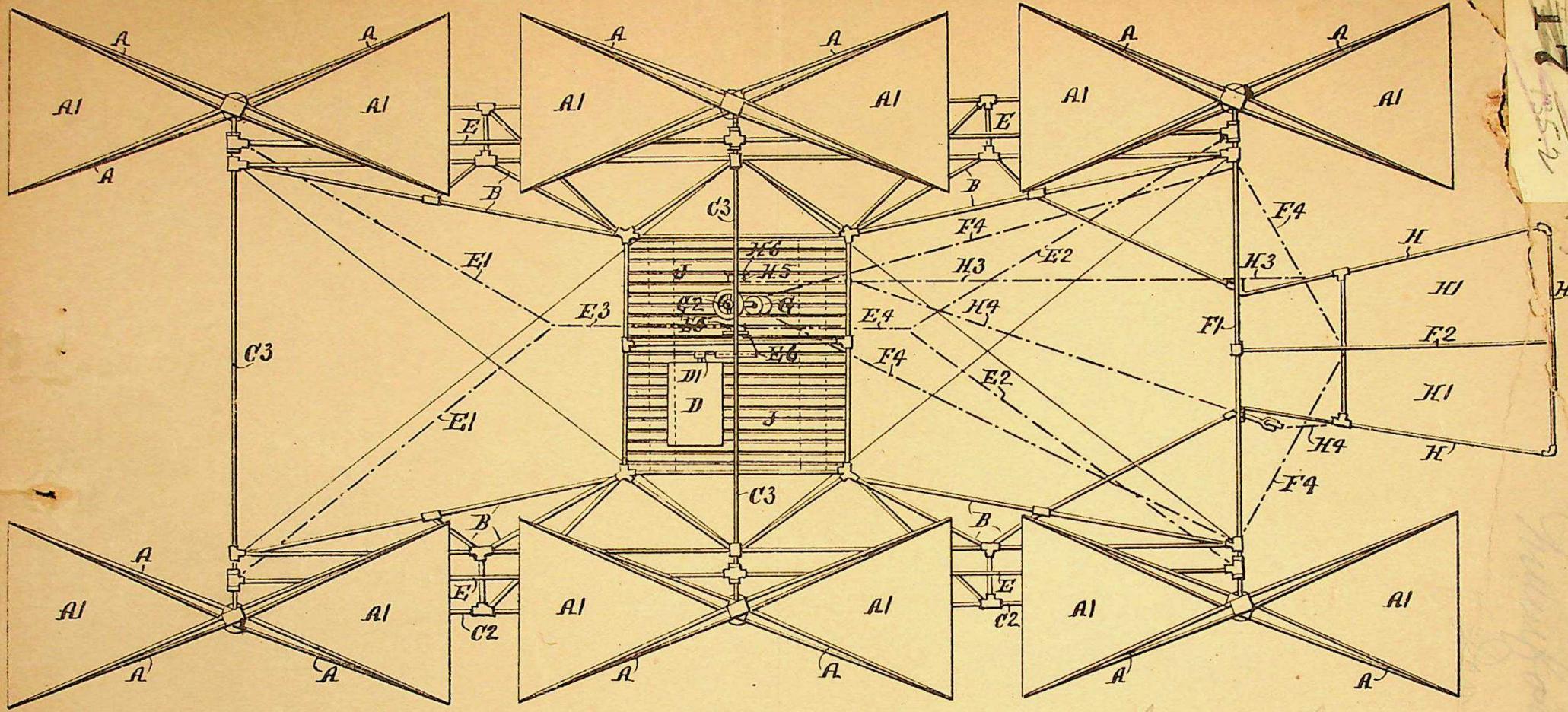
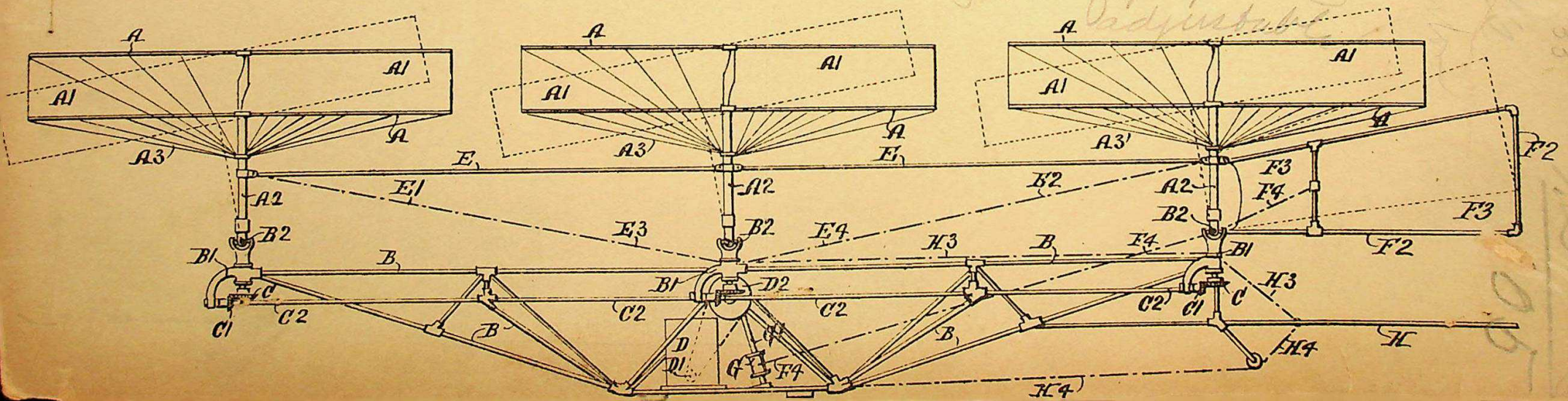

A
A1
A3
B
B1
B2
C
C1
C2
C3
D
D1
D2
E
E1
E2
E3
E4
F
F1
F2
F3
F4
G
H
H1
H3
H4
H5
H6
J

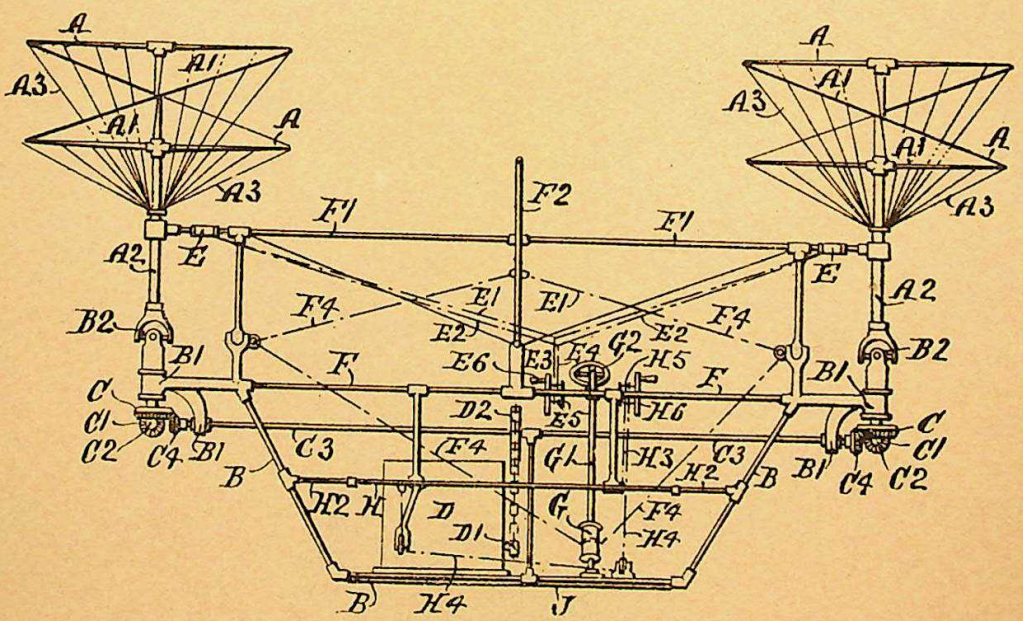
FIG. 2.


A
A1
A3
A3'
B
B1
B2
C
C1
C2
D
D1
D2
E
E1
E2
E3
E4
F
F2
F3
F4
G
H3
H4
H
Plane of propellers
adjustable

A.D. 1905. FEB. 16. N° 3214.
MUMFORD'S COMPLETE SPECIFICATION.

[2 SHEETS
SHEET 2.

FIG. 3.



[This Drawing is a reproduction of the Original on a reduced scale.]

244-19

N° 3214 A.D. 1905

DUPLICATE

Date of Application, 16th Feb., 1905
Complete Specification Left, 14th Aug., 1905—Accepted, 2nd Nov., 1905

PROVISIONAL SPECIFICATION.

"Improvements in or connected with Aerodromes or Flying Machines"

I, EDWIN RICHARD MUMFORD, of Lynton House, Dumbarton, in the County of Dumbarton, North Britain, Naval Architect, do hereby declare the nature of this invention to be as follows:—

My invention relates to aerodromes or flying apparatus of the kind which is heavier than air and in which screw propellers are used to raise the machine to, and to maintain it at the desired height in the air and to propel it in any desired direction, and has for its object to provide an improved, simple, and effective apparatus in which the same propellers are utilised for suspension and propulsion; and in which the proportions and numbers of the propellers and the power they transmit conjointly bear a definite relation to the weight of the whole apparatus.

An aerodrome, made according to my invention, comprises a light framework or hull of bamboo, aluminium, or other suitable material and provided with means for carrying the motor or motors driving the apparatus and for accommodating the operators. More or less horizontal plane surfaces, preferably of textile material stretched upon suitable light but rigid frames are attached to either end of the hull and are provided with means under control of the operator for altering their inclination. The textile material is preferably laced upon or otherwise secured to the frames so as to be readily removable. These plane surfaces serve to balance the machine and afford a certain degree of additional safety should the propelling machinery break down.

A rudder of similar construction to the frames but in a vertical plane is provided at either end of the hull and is similarly under control of the operator for steering purposes.

The combined suspensory and propulsive screw propellers are arranged above the hull upon shafts which may be moved more or less from the vertical in the longitudinal vertical plane of the apparatus. There are at least two equal propellers, or there may be any convenient multiple of two, one half of their number being right-handed and the other half left-handed so as to eliminate any horizontal turning couple; or the propellers may be otherwise proportioned and arranged to this end. The propeller shafts are connected by suitable flexible joints or other connections to the shaft or shafts of a motor or motors operated by any suitable power; for example, combustible vapour or gas, and preferably arranged below the hull so that all the weight of the hull, motors, and operators is below the suspensory propellers, *i.e.* the point of suspension of the machine when it is in the air.

The inclination of the propellers within the predetermined limits is under the control of the operator. When they are vertical their effort is entirely towards the suspension of the apparatus; as they become inclined, their effort is divided into two components, one suspensory, the other propulsory, so that, by adjusting the angles at which the propellers operate, the machine may be raised vertically, or maintained at a constant elevation and propelled horizontally, or propelled in any direction desired between the vertical and horizontal, while

[*Price 8d.*]

its movements in a horizontal plane are controlled by the rudder, and further modifications of its movements may be attained by varying the speed of rotation of the propellers.

The propeller blades are preferably formed from frames of bamboo, aluminium or other suitable material covered with textile fabric or the like laced upon them so as to be readily removable. The dimensions and number of the propellers and the power of the motor driving them are definitely proportioned to the total weight to be raised and the following is given by way of example of these proportions:—In a machine having a total weight of hull, gearing and load not exceeding 350 lbs. four propellers are used of a diameter of 40 feet, a projected area of 600 square feet and transmitting 20 H.P. from a petrol motor weighing not more than 220 lbs.

The total area of the propellers is, in this case, sufficiently great for them to act as safe parachutes for the total weight in the case of breakdown of the motor and they are preferably made in all cases of an area sufficient for this purpose.

Dated this Fifteenth day of February 1905

EDMUND HUNT & Co.
Chartered Patent Agents,
121 West George Street, Glasgow,
Applicant's Agents.

COMPLETE SPECIFICATION.

"Improvements in or connected with Aerodromes or Flying Machines"

I, Edwin Richard Mumford, of Lynton House, Dumbarton, in the County of Dumbarton, North Britain, Naval Architect, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

My invention relates to aerodromes or flying apparatus of the kind which is heavier than air and in which screw propellers are used to raise the machine to, and to maintain it at the desired height in the air and to propel it in any desired direction, and has for its object to provide an improved, simple, and effective apparatus of the type in which the same propellers are utilised for suspension and propulsion; but in which the proportions and numbers of the propellers and the power they transmit conjointly bear a definite relation to the weight of the whole apparatus.

Hitherto it has never been proposed to use more than two propellers. When these were arranged upon the same shaft, their efficiency (both as regards thrust per weight and thrust per H.P. transmitted) was obviously much reduced; and, even when they were arranged upon separate shafts their area (in order that they might adequately support the weight of the apparatus) had to be inordinately great; for, although it may appear that area, speed of revolution, and pitch of the propellers employed are interchangeable factors, it has been found that it is not so, and that area (and, secondarily, pitch) is the essentially determining factor. Now, it has been found in practice impossible to make one or two propellers (it being borne in mind how light their construction must be) which will support a reasonable weight of frame, propelling machinery, and load. Furthermore, it is obvious that a single propeller (or two propellers) has very little lateral stability. Therefore, in order that the required aggregate propelling area and, at the same time, sufficient stability may be attained, I, according to my invention, use at least four—and preferably more—propellers,

the area, the pitch, and the speed at which they are driven being substantially proportionate to the example hereinafter given.

An aerodrome, made according to my invention, comprises a light framework or hull of bamboo, aluminium, or other suitable material and provided with means for carrying the motor or motors driving the apparatus and for accommodating the operators. More or less horizontal plane surfaces, preferably of textile material stretched upon suitable light but rigid frames, may be attached to either end of the hull and be provided with means under control of the operator for altering their inclination. The textile material is preferably laced upon or otherwise secured to the frames so as to be readily removable. These plane surfaces serve to give an additional means of adjusting the angle of flight and also to balance the machine, at the same time affording a certain degree of additional safety should the propelling machinery break down. Balance may also be assisted by movements of the operators or of a weight.

A rudder of construction similar to these plane surfaces but in a vertical plane is provided at one or both ends of the hull (when there is only one rudder it is preferably at the after end). The rudder (or rudders) is under the control of the operator.

The combined suspensory and propulsive screw propellers are arranged above the hull upon shafts which may be moved more or less from the vertical in the longitudinal vertical plane of the apparatus in known manner. It has been found that sufficient area to obtain the desired lifting force cannot practically be attained with two propellers, there are therefore four or there may be any other convenient multiple of two, one half of their number being right-handed and the other half left-handed so as to automatically eliminate any horizontal turning couple; or the propellers may be otherwise proportioned and arranged to this end. The propeller shafts are connected by suitable flexible joints or other connections to the shaft or shafts of a motor or motors operated by any suitable power; for example, combustible vapour or gas, and preferably arranged below the propellers so that all the weight of the hull, motors, and operators is below the suspensory propellers, *i.e.* the point of suspension of the machine when it is in the air.

The inclination of the propellers within the predetermined limits is under the control of the operator. When the axes of the propellers are vertical or in a vertical transverse plane their effort is entirely towards the suspension of the apparatus; as they become inclined longitudinally their effort is divided into two components, one suspensory, the other propulsory, so that, by adjusting the angles at which the propellors operate, the machine may be raised vertically, or maintained at a constant elevation and propelled horizontally, or propelled in any direction desired between the vertical and horizontal, while its movements in a horizontal plane are controlled by the rudder, and further modifications of its movements may be attained by varying the speed of rotation of the propellers.

For the sake of simplicity, the propeller shafts may be fixed at a determinate angle and the relative proportions of the vertical and horizontal velocity components of the apparatus when in flight be adjusted by varying the speed at which the propellers are rotated.

In order that the invention may be more readily understood there are hereunto appended two sheets of explanatory drawings showing diagrammatically an example of the improved aerodrome having six propellers mounted upon shafts the inclination of which is variable; Figures, 1 and 2, Sheet, 1, being respectively a plan and a side elevation, while Figure, 3, Sheet, 3, is an end elevation—like parts being indicated throughout by like reference letters and numerals.

Six propellers are used in this example. They are built up of light bamboo arms, A, upon which are laced screens, A^1, of light textile material. The

propellers are carried on shafts, A^2, from which the arms, A, are stayed by guys, A^3. The shafts, A^2, with their propellers are arranged three at either side of the hull structure which is built up of bamboo rods, B, united by lugs and are carried in brackets, B^1, there being universal ("Hooke's") joints, B^2, in the shafts above the brackets. The shafts are driven through bevil wheels, C, secured to their ends below the brackets from bevil wheels, C^1, on longitudinal shafts, C^2, (one at either side of the structure) which in their turn are driven from a transverse shaft, C^3, by bevil wheels, C^4, which gear with the bevil wheels, C, of the two central propeller shafts, A^2. The transverse shaft, C^3, is driven from a motor, D,—preferably a petrol motor—through sprocket wheels, D^1, D^2, and a pitch chain. The propellers upon opposite sides of the apparatus are of opposite hand, so that their turning reactions on the hull are balanced.

It will be seen that the universal joints, B^2, permit of the shafts, A^2, and their propellers being angled to any desired extent. The various shafts, A^2, are constrained to move together as regards angling and in the vertical longitudinal plane of the apparatus by links, E, connecting these shafts together, while the forward and rear shafts are moved in either direction by operating wires, E^1, E^2, (the operating wires for all parts of the apparatus are indicated in the drawings by chain lines). The wires, E^1, E^2, are connected to wires, E^3, E^4, which are wound in opposite directions upon a drum, E^5, carried in the framing of the apparatus and provided with a handwheel, E^6, by rotating which in one direction the wires, E^1, E^3, at the forward end of the apparatus are hauled in and those, E^2, E^4, at the after end paid out a like extent so inclining the propellers and their shafts, A^2, as shown by dotted lines in Figure, 2, and to any desired extent; and by rotating which in the opposite direction the wires, E^1, E^3, are paid out and those, E^2, E^4, hauled in so returning the shafts, A^2, to their vertical position (it is not intended that they be inclined rearwardly of their vertical position except possibly when alighting. Thus the shafts, A^2, and their propellers may be inclined, in the manner and for the purposes hereinbefore described, to any desired extent within the predescribed limits.

A transverse member, F, connecting the two aftermost brackets, B^1, and a shaft, F^1, connecting the corresponding shafts, A^2, (there being collars upon the ends of the shaft, F^1, through which these shafts, A^2, pass) carry between them at the centre an arm carrying the vertical rudder hereinbefore referred to and by which steering in a horizontal plane is accomplished. This rudder consists of a light frame work, F^2, hinged upon the arm and having laced upon it textile material, F^3. It is operated for steering by wires, F^4, attached to it passing round guide pulleys at the after corners of the hull and from thence in opposite directions around a drum, G, carried on an inclined shaft, G^1, and provided with a handwheel, G^2, by which the rudder is operated. It will be seen that with this arrangement the vertical rudder tilts with the inclining of the shafts, A^2, as shown in dotted lines in Figure, 2.

A horizontal rudder for controlling the movements of the apparatus in a vertical plane to some extent is also provided and this consists of a light framework, H, covered with textile material, H^1, and hinged to a rearward cross member, H^2, of the hull framing. This rudder is operated to vary its inclination by wires, H^3, H^4, secured to it passing round guide pulleys in the framing and to a drum, H^5, provided with a handwheel, H^6, and around which they pass in opposite directions and by turning which by the handwheel, H^6, the rudder may be upwardly or downwardly inclined as desired.

A floor, J, composed of slats supports the motor, D, (which is of course provided with the usual controlling gear and fuel and cooling water tanks and arrangements) the various devices (for controlling the shafts, A^2, and the rudders) and the operators while movable weights (in addition to the operators) may be arranged upon it for adjusting the balance of the apparatus.

The example described has only been given by way of illustration and it is

clear that the construction of the apparatus may be widely varied without departing from the essence of the invention. For instance, the number of propellers used may be varied and their paths may be made to overlap in a transverse or fore-and-aft direction or in both directions—that is to say, they may be so connected to their gearing that their arms mesh after the manner of teeth in gear but, of course, without touching—in this manner although the propellers lose a certain amount of efficiency because of their overlapping yet is advantage gained in the reduced size and consequent reduced weight of the apparatus as a whole. Also it is clear that the rudders may be duplicated at opposite ends of the apparatus or horizontal rudders may be arranged at the sides of the apparatus or additional steadying and supporting planes be provided if desired.

In the example of aerodrome shown and described and in any apparatus made according to the invention, the dimensions and numbers of the propellers and the power of the motor driving them are definitely proportioned to the total weight to be raised and the following is given by way of example of these proportions and as definitely showing the relations of these integers:—In a machine having a total weight of hull, motor, gearing, and load not exceeding 900 lbs, six propellers are used each of a diameter of about 25 feet, each of about 25 feet pitch, and each having a horizontally projected area of about 125 square feet (the total disc area—that is, the area covered by the blades when revolving—being in all about 2950 square feet, while the total flat area—*i.e.* the area of one side of the blades—is in all about 1,000 square feet, this area projected on the plane of revolution being about 750 square feet). These six propellers are driven at about 40 revolutions per minute by a motor weighing about 250 lbs. and developing about 30 H.P. Thus it will be seen that for each pound of total load raised, the disc area of the propellers is about 3 square feet, the flat area of the blades is fully one square foot and their area projected on the plane of rotation is fully 0.8 of a square foot, while the power provided per pound of load is $\frac{1}{30}$th H.P. This for ascension, for horizontal flight much less power is necessary.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

—1— An aerodrome having not less than four propellers all acting both for suspension and propulsion, as described.

—2— An aerodrome having not less than four propellers all acting both for suspension and for propulsion and arranged in equal numbers on either side of the longitudinal centre line of the apparatus, as described.

—3— An aerodrome having not less than four combined suspensory and propulsory propellers carried upon shafts the axes of which are normally and when the apparatus is in horizontal flight inclined in the longitudinal vertical plane of the apparatus, as described.

—4— An aerodrome having not less than four combined suspensory and propulsory propellers carried upon shafts the axes of which are normally and when the apparatus is in horizontal flight inclined in the longitudinal plane of the apparatus, the propellers being arranged in equal numbers on either side of the longitudinal centre line of the apparatus, as described.

—5— An aerodrome having a plurality of propellers the aggregate disc area of which is substantially 3 square feet per pound to be lifted and which are adapted to use about $\frac{1}{30}$th H.P. for each pound of total load, substantially as described.

—6— An aerodrome having a plurality of propellers the aggregate area of which is substantially 3 square feet for each pound of total load, substantially as described.

Improvements in or connected with Aerodromes or Flying Machines.

—7— In an aerodrome of the type described; propellers of opposite arranged upon opposite sides of the longitudinal centre line of the ap as described.

Dated this Twelfth day of August, 1905.

EDMUND HUNT & Co.
Chartered Patent Agents
121 West George Street, Gla
Applicant's Agents.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.-